SERVICE TO THE STATE OF UTAH

GEOLOGICAL AND MINERAL SURVEY UTAH

SURVEY NOTES

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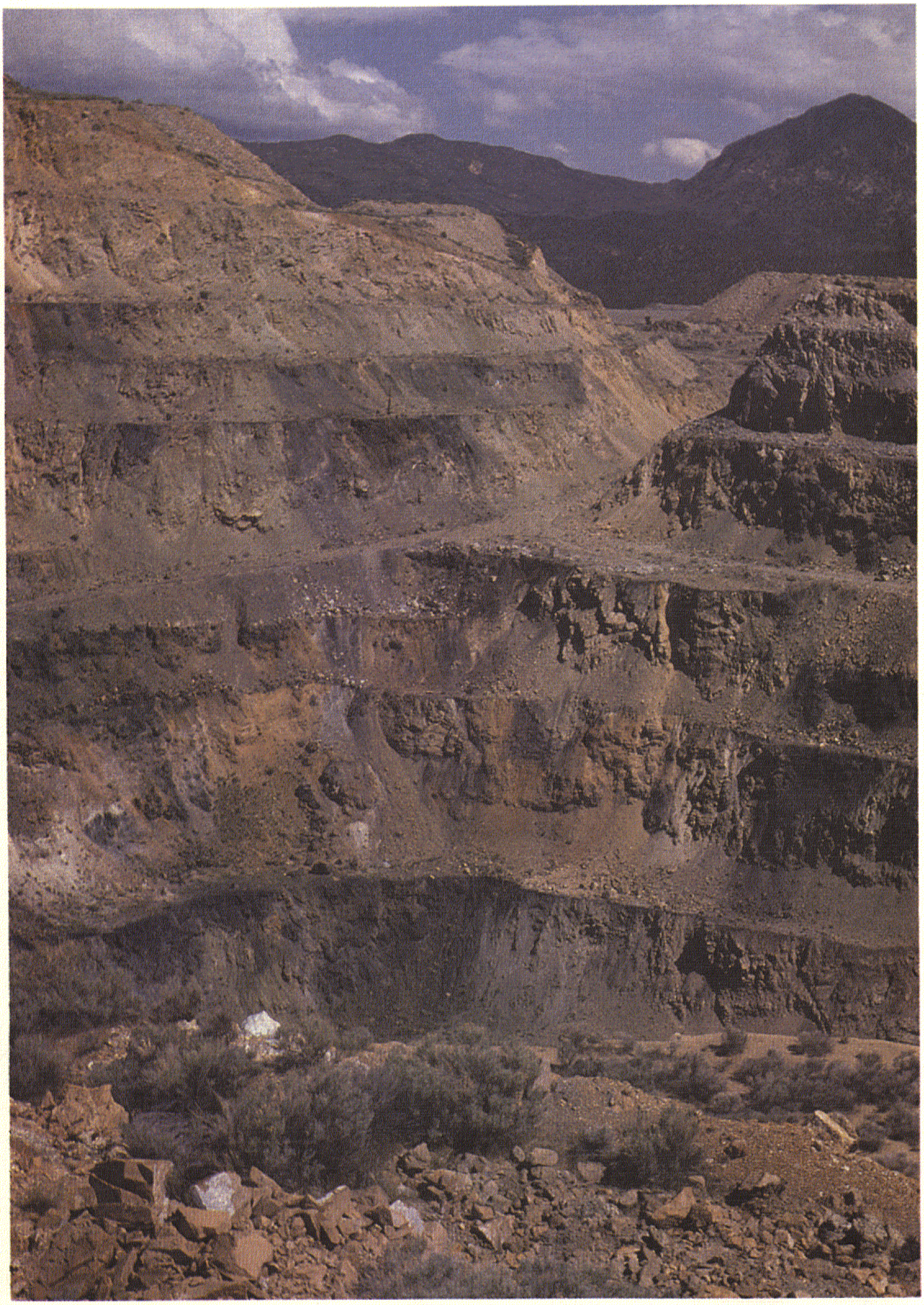

MINING DISTRICT STUDIES

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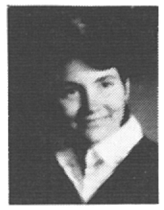
Cover: View looking southeast across the northern part of the Burke mine.

Survey Notes is published quarterly by **Utah Geological and Mineral Survey**, 606 Black Hawk Way, Salt Lake City, Utah 84108 (801) 581-6831. The UGMS inventories the geologic resources of the state, identifies its geologic hazards, disseminates information concerning Utah's geology, and advises policymakers on geologic issues. The UGMS is a division of the Department of Natural Resources. Single copies of Survey Notes are distributed free of charge to residents within the United States and Canada. Reproduction is encouraged with recognition of source.



FROM THE DIRECTOR'S DESK

The Mining Industry of Utah Role of the UGMS

Historically, mineral production has contributed to the health of Utah's economy, providing an economic base for many communities. In recent years, the mining industry has fallen on hard times and the state has witnessed a remarkable decline in its mining industry. In 1981, metallic mineral production in the state reached its peak with a value totaling over 709 million dollars. Employment in the mining industry also peaked in 1981, accounting for 3.6 percent of the state's non-agricultural work force. By 1984, the last year for which complete statistics are available, the value of the state's mineral production dropped to 423 million, a decrease of 40 percent in only three years. Employment also dropped, with mining (including coal and oil and gas) accounting for 2 percent of the state's workers and metallic mining accounting for .7 percent of the work force. Production from Kennecott's Utah Copper Division has, until recently, accounted for approximately one-half of the state's annual metallic mineral production. With the temporary closure of Kennecott's operations in March of 1985, Utah's estimated mineral production for 1986 was on the order of 200 million dollars, representing a decrease of about 70 percent since 1981.

This decline of the mining industry is not restricted to Utah. National production statistics show a similar history and forecasts do not show any relief for the mining industry in the near future. With this bleak picture in mind, one might wonder why the UGMS continues to conduct mining district studies designed to encourage mineral development. One might ask 'what could the UGMS possibly do to help the terminally ill mineral industry?'

Mining District Studies

UGMS mining district program consists of only one principle investigator, a mineral geologist, who maps the economic geology of Utah's mining districts one by one. Each district takes a couple of years. The purpose of these projects is to present the geology and economic potential of an individual mining district which has not received much attention or not been exploited for awhile. In the process of the study, the geologist collects and analyses information about the mining district and trys to determine the origin of the ore and its manner of occurrence. Utah probably has many important mineral deposits that have not yet been discovered, and by understanding the geology of a mining district the UGMS not only develops information about that district but also increases the potential to locate undetected deposits hidden elsewhere in the state.

Technical Assistance

With the exodus of many companies from the minerals exploration industry, much of the current exploration is being done by prospectors, ranchers, rockhounds, and others with little formal education in economic geology. Mining district studies in lesser known districts help amateurs aid industry efforts by outlining "target areas," areas which have a higher probability for the discovery of a particular type of mineral deposit. The studies also describe what exploration methods might be useful and what characteristics should be viewed as favorable. An example of this technical assistance is the use of geochemistry: a district study provides the information necessary to know whether or not a particular assay is significant and should be followed up with more work or if it is "average" for that area.

Surviving minerals exploration companies are much smaller and fewer in number than five years ago, often subsisting on greatly reduced budgets and targeting their efforts in areas where the regional geologic information has been collected. Mining district studies supply

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THE ANTELOPE RANGE MINING DISTRICT STUDY

An Integrated Approach to Mineral Resource Appraisal

by Michael Shubat

Minerals exploration and the closely related field of mineral resource appraisal have come a long way from the days of the early prospectors, and they now draw on a wide range of scientific disciplines. In today's search for new deposits of gold, silver, and other valuable metals, a successful exploration program combines aspects of such diverse fields as geology, geochemistry, geophysics, and remote sensing. Thus, to best serve the exploration community, the Utah Geological and Mineral Survey (UGMS) has adopted an integrated approach to its mining district study program. The recently completed Antelope Range mining district study (Shubat and McIntosh, 1987) serves as an example of this approach.

Exploration programs are founded on mineral-deposit models, which attempt to predict where a certain type of deposit is likely to occur and the possible size of such a deposit. A large amount of data is required to formulate mineral-deposit models and an equally large amount of information is needed to select areas with favorable geological characteristics that warrant exploration. Thus, one of the goals of the Utah Geological and Mineral Survey is to provide this needed data to the exploration community in the form of mining district studies. The role of the UGMS and other governmental agencies in providing essential and basic data to exploration companies is especially important during the current period of depressed exploration activity.

Although mainly a product of the UGMS, the Antelope Range district study benefited greatly from the cooperation of private industry and academia. Two major minerals exploration companies donated large amounts of geochemical and drilling hole data pertaining to the district. A graduate student from Colorado State University also participated in the study, contributing detailed information on the ore mineralogy and environment of ore deposition (McIntosh, 1987). The study also benefited from cooperation between the Economic and Mapping programs of the UGMS. Geologic mapping of the area surrounding the mining district (the Silver Peak 7-1/2′ quadrangle; Shubat and Siders, 1987), as part of the UGMS quadrangle mapping program, permitted a better understanding of the structural and stratigraphic history of the area.

The Antelope Range mining district is located in north-central Iron County, approximately 20 miles west of Cedar City, Utah (figure 1). Although historically not a large producer, the district has potential for undiscovered economic deposits of silver with accessory concentrations of gold, lead, zinc, and copper. Known areas of silver mineralization are restricted to quartz veins, similar in many respects to the nearby Escalante silver mine. The Antelope Range district study will be published as a UGMS Special Study, and the geologic map of the Silver Peak 7-1/2′ quadrangle, which covers most of the district, will be published as part of the UGMS map series.

GEOLOGY

The foundation for any mineral resource appraisal is a thorough understanding of the geology. As with any field-oriented geological study, the stratigraphy of an area must first be defined. In the Antelope Range district, the stratigraphy is dominated by Tertiary volcanic rocks (figure 2) ranging in age from 26 to 8.5 million years

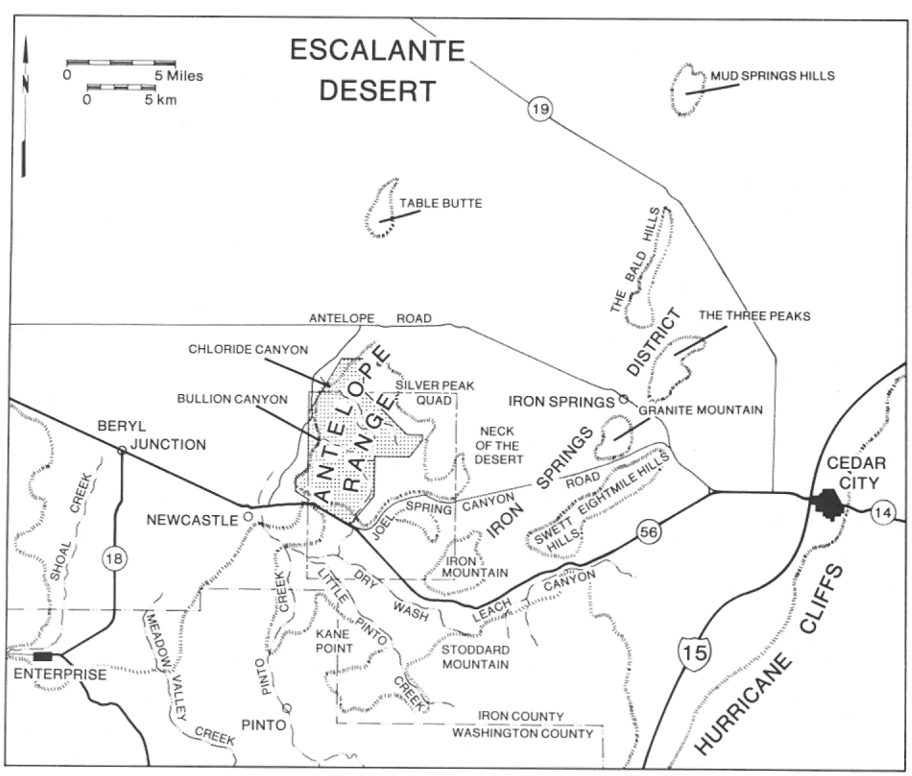


Figure 1. Map showing the location of the Antelope Range mining district (stippled) and the Silver Peak quadrangle.

(m.y.) old. Relatively precise ages have been determined for these rocks by carefully measuring the amount of certain isotopes produced by the radioactive decay of potassium (Armstrong, 1970). These rocks, mainly ash-flow tuffs, were erupted from calderas located mostly in southeastern Nevada and cover large areas of southwestern Utah (Rowley and others, 1979; Siders and Shubat, 1986). Volcanic rocks in southwestern Utah fall within two broad categories: those related to subduction of oceanic crust (calc-alkaline rocks older than 21 m.y.) and those produced by crustal extension (bimodal volcanics younger than 21 m.y.; Rowley and others, 1979; Steven and Morris, 1984).

Sedimentary rocks underlie the volcanic rocks and range in age from Jurassic to early Tertiary. Limestone of the Carmel Formation was deposited during a brief marine invasion during the Jurassic Period. Clastic rocks of the Iron Springs and Claron Formations (figure 2) were derived from erosion of a highland to the west created during the Late Cretaceous Sevier orogeny.

With a firm grasp on stratigraphy, the structure of an area can be defined. Mapping in the Antelope Range district and Silver Peak quadrangle reveals a complex history of faulting, folding, and doming related to igneous intrusion (figure 3). A structural interpretation of the area (Shubat and Siders, 1987) based on field relations suggests that most of the northwest-trending faults in the district were produced between 21 and 8 m.y. ago in response to northeast-directed crustal extension. Faults produced during this period of deformation are important in that they host most of the vein deposits in the district. A younger fault produced the modern topography. This fault separates the Escalante Valley from the Antelope Range (figure 3) and truncates older structures and mineralized veins. Available data suggest that the valley has been downdropped as much as 10,000 feet relative to the range and that the fault is still active. A thrust fault, produced during an older period of deformation (Late Cretaceous in age), underlies the Antelope Range. As a result of this deformation, all pre-Tertiary rocks in the district were transported to their present locations from areas to the west.

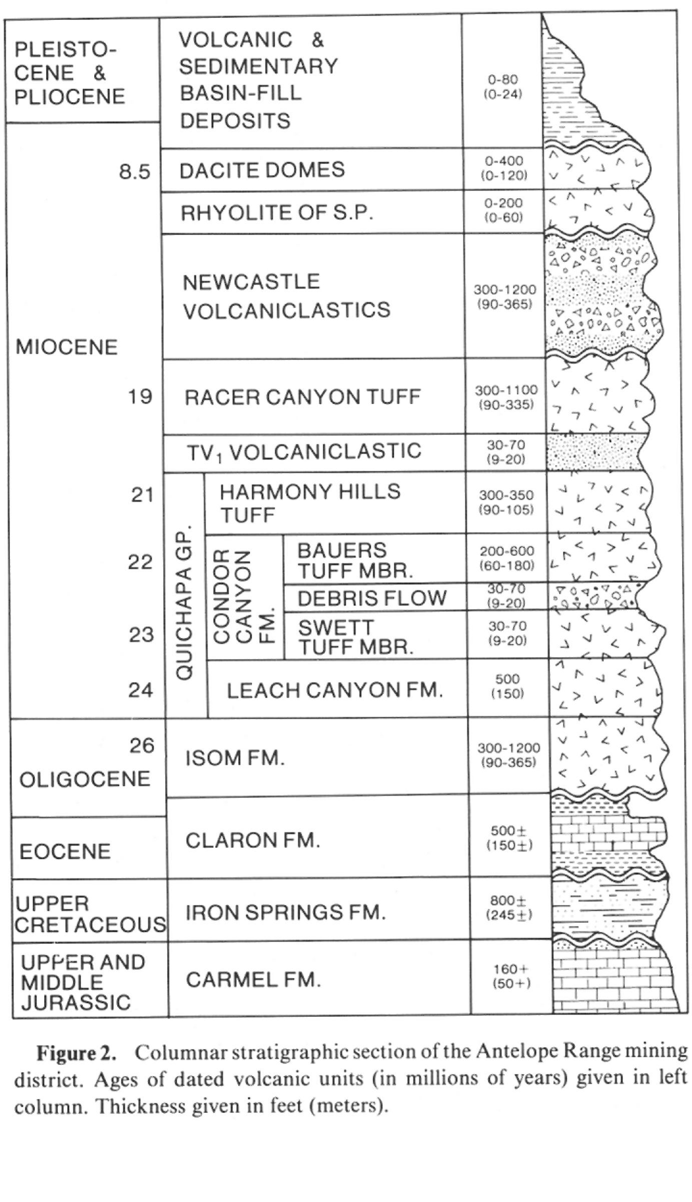


Figure 2. Columnar stratigraphic section of the Antelope Range mining district. Ages of dated volcanic units (in millions of years) given in left column. Thickness given in feet (meters).

HYDROTHERMAL ALTERATION

A close relationship has long been noted between hydrothermal alteration and economic mineral deposits; for this reason hydrothermal alteration mapping is an important aspect of mineral exploration and mineral resource appraisal. Hydrothermal alteration is produced by the interaction between hydrothermal solutions (hot water) and host rocks. Alteration zones are typically defined in terms of the mineral assemblages comprising the zones. Identification of alteration minerals involves the use of x-ray diffraction and petrographic techniques. In the Antelope Range district, a broad area of kaolinitic alteration (also known as argillic or clay alteration) was defined that fringes more intense zones of silicification (replacement by quartz) adjacent to veins and stockwork zones. Mineralized areas were found to be associated with sparse potassium-bearing minerals such as adularia and sericite.

GEOCHEMISTRY

Geochemical studies in the past have shown that economic mineral deposits are often fringed by subtle (measurable in parts per million) enrichments in suites of indicator (or pathfinder) elements. As an example, many gold and silver deposits are overlain by zones enriched in arsenic, antimony, and mercury and are underlain by zones enriched in copper, lead, and zinc. Geochemical zones such as these are produced by boiling of hydrothermal solutions and are a function of differing solubilities of chemical species in the solutions. Details of geochemical zonation vary greatly between districts and even between deposits in the same district. For the Antelope Range district, a data base consisting of over 1,900 geochemical analyses of rock samples was used to define geochemical zones. Statistical processing of these data was accomplished using UGMS computer facilities. Results from geochemical studies show that: (1) vertical zonation is characterized by deeper base metal (and molybdenum) enrichment and higher precious metal enrichment, (2) lateral zonation is reflected by markedly different gold-silver ratios in parallel vein systems, and (3) factor analysis results corroborate the paragenetic studies (see below). Factor analysis is a statistical technique that allows one to redefine the original variables of a data base (in this case the concentrations of various elements) in terms of mutually independent factors while preserving as much of the original variance of the data base as possible. These factors are then interpreted in terms of the processes that lead to their observed distribution.

MINERALIZATION

Ore samples from the Antelope Range district were investigated using a variety of techniques including ore microscopy, x-ray diffraction analysis, and fluid inclusion studies. Textures of ore and gangue minerals observed under the microscope were used to

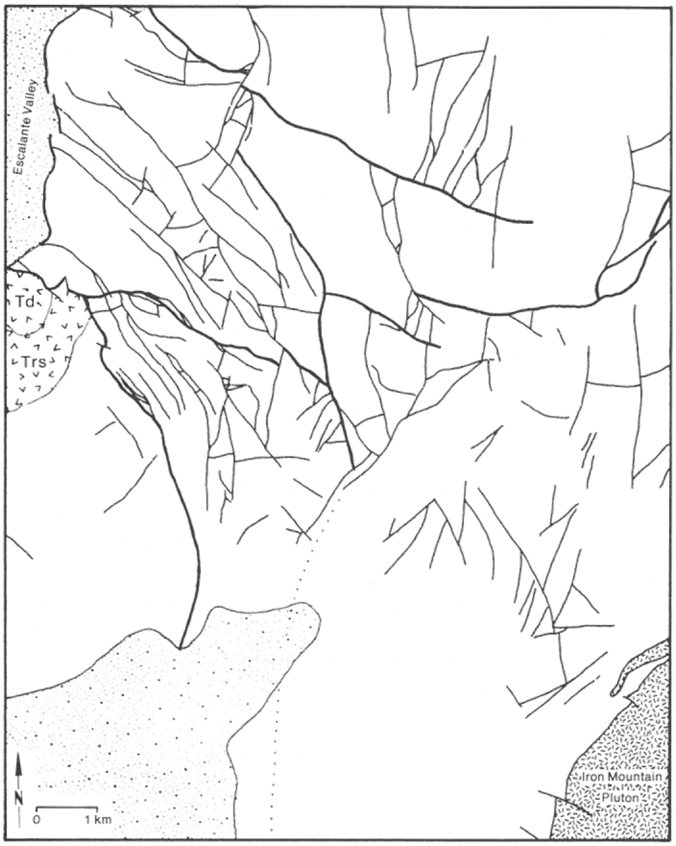


Figure 3. Mapped faults of the Silver Peak quadrangle. Stippled areas underlain by thick Quaternary deposits. Td and Trs are upper Miocene volcanic units. Location of the Iron Mountain pluton also shown. Northwest-striking faults in the west-central portion of the quadrangle are hosts for veins in the Antelope Range district.

determine a paragenetic sequence or, in other terms, the detailed history of the sequence in which the minerals were precipitated in the veins. Results of these studies show that ore minerals consist of base metal sulfides (galena, chalcopyrite, and sphalerite) and silver sulfosalts. Ore minerals were deposited in association with quartz, calcite, and barite as open space fillings. Textures and fluid inclusion studies show that ore minerals were deposited from boiling solutions over a temperature range of 198° to 205°C and that two stages of mineralization are present, an early base metal stage and a later precious metal stage. Oxidation of these primary minerals produced a variety of secondary minerals such as cerussite, malachite, and hematite.

SYNTHESIS OF DATA

The last step in a mineral resource appraisal is to synthesize the seemingly disjointed array of data collected during the study. In doing this, one searches for a genetic process which accounts for the interrelationships between the observed hydrothermal alteration zonation, geochemical zonation, and mineralogical zonation of ore and gangue minerals. This seemingly difficult task is facilitated by classifying the deposits of a district in terms of deposit-type models or occurrence-models (Erickson, 1982; Cox, 1983a;b). In practice, one first classifies a particular deposit into a general category and then refines the classification according to more detailed models with comparisons to specific deposits. As an example, the Mercur deposit may first be identified as an epithermal gold deposit with a more refined classification as a carbonate-hosted disseminated gold deposit with very specific characteristics. For many deposit-types, grade-tonnage models have been derived (Singer and Mosier, 1983a;b) that permit estimates to be made of the size and richness of undiscovered deposits.

Mineralization in the Antelope Range district may be classified as the epithermal baseand precious-metal vein type (Buchanan, 1981; Berger and Eimon, 1983). This classification may be further refined as the adularia-sericite subtype of Heald and others (in review). A simplified genetic model for mineralization in the district may be stated as follows:

> Northwest-striking faults, formed during mid-Miocene extension, preceded mineralization. Heat derived from the emplacement of rhyolitic magmas during the late Miocene induced the circulation of hydrothermal solutions along the northwest-striking faults. Hydrothermal solutions rising along the faults boiled as they approached the surface. At least two boiling events occurred, a first, depositing base-metal sulfides and a second, depositing silver sulfosalts. A possible third boiling event may have produced a relatively gold-rich vein system. Boiling is probably the dominant process that led to ore and gangue mineral deposition in the veins.

Once a genetic model has been formulated, it is used to predict fruitful areas to explore for deposit-types known to occur in the district. In addition, the model may be used to predict where related deposit types may exist and to develop exploration strategies.

CONCLUSIONS

Investigations such as the Antelope Range district study are designed to assist the exploration community in the search for new deposits by providing basic data which can be incorporated into exploration strategies. Conclusions reached in the Antelope Range study were based on current genetic models of ore deposits, which are bound to change with time. Thus, although mineralized areas of the Antelope Range district may not warrant immediate economic development, future generations may conduct successful exploration programs with new ideas and new concepts.

REFERENCES

Armstrong, R.L., 1970, Geochronology of Tertiary igneous rocks, eastern Basin and Range Province, western Utah, eastern Nevada, and vicinity, U.S.A.: Geochimica et Cosmochimica Acta, v. 34, no. 2, p. 203-232.

Berger, B.R., and Eimon, P., 1983, Conceptual models of epithermal precious-metal deposits; *in* Shanks, W.C., III (ed.), Cameron volume on unconventional mineral deposits: Society of Mining Engineers, American Institute of Mining and Metallurgy, p. 292-305.

Buchanan, L.J., 1981, Precious-metals deposits associated with volcanic environments in the southwest; *in* Dickinson, W.R., and Payne, W.D., (eds.), Relations of tectonics to ore deposits in the south Cordillera: Arizona Geological Society Digest, V. 14, p. 237-262.

Cox, D.P., ed., 1983a, U.S. Geological Survey Ingeominas mineral resource assessment of Columbia: Ore deposit models: U.S. Geological Survey Open-file report 83-423, 64 p.

Cox, D.P., ed., 1983b, U.S. Geological Survey Ingeominas mineral resource assessment of Columbia: Additional ore deposit models: U.S. Geological Survey Open-file report 83-901.

Erickson. R.L., compiler, 1982, Characteristics of mineral deposit occurrences: U.S. Geological Survey Open-file Report 82-795, 248 p.

Heald, P., Hayba, D.O., and Foley, N.K., in review, comparative anatomy of volcanic-hosted epithermal deposits: Acid-sulfate and adularia-sericite types: Economic Geology.

McIntosh, W.S., 1987, Geology and mineralization of the Bullion Canyon area, Iron County, Utah: Fort Collins, Colorado State University, unpublished Master's thesis (in progress).

Rowley, P.D., Steven, T.A., Anderson, J.J., and Cunningham, C.G., 1979, Cenozoic stratigraphic and structural framework of southwestern Utah: U.S. Geological Survey Prof. Paper 1149, 22 p.

Shubat, M.A., and McIntosh, W.S., 1987, Geology and mineral potential of the Antelope Range mining district, Iron County, Utah: Utah Geological and Mineral Survey (in review).

Shubat, M.A., and Siders, M.A., 1987, Geologic map of the Silver Peak 7-1/2′ quadrangle, Iron County, Utah: Utah Geological and Mineral Survey (in review).

Siders, M.A., and Shubat, M.A., 1986, Stratigraphy and structure of the northern Bull Valley Mountains and Antelope Range, Iron County, Utah; *in* Griffen, D.T., and Phillips, W.R., eds., Thrusting and extensional structures and mineralization in the Beaver Dam Mountains, southwestern Utah: Utah Geological Association Publication 15, p. 87-102.

Singer, D.A., and Mosier, D.L., eds., 1983a, Mineral deposit grade-tonnage models: U.S. Geological Survey Open-file Report 83-623, 100 p.

Singer, D.A., and Mosier, D.L., eds., 1983b, Mineral deposit grade-tonnage models II: U.S. Geological Survey Open-file Report 83-902, 101 p.

Steven, T.A., and Morris, H.T., 1984, Mineral resource potential of the Richfield 1° x 2° quadrangle, west-central Utah: U.S. Geological Survey Open-file Report 84-521, 53 p. ■

UTAH EARTHQUAKE ACTIVITY

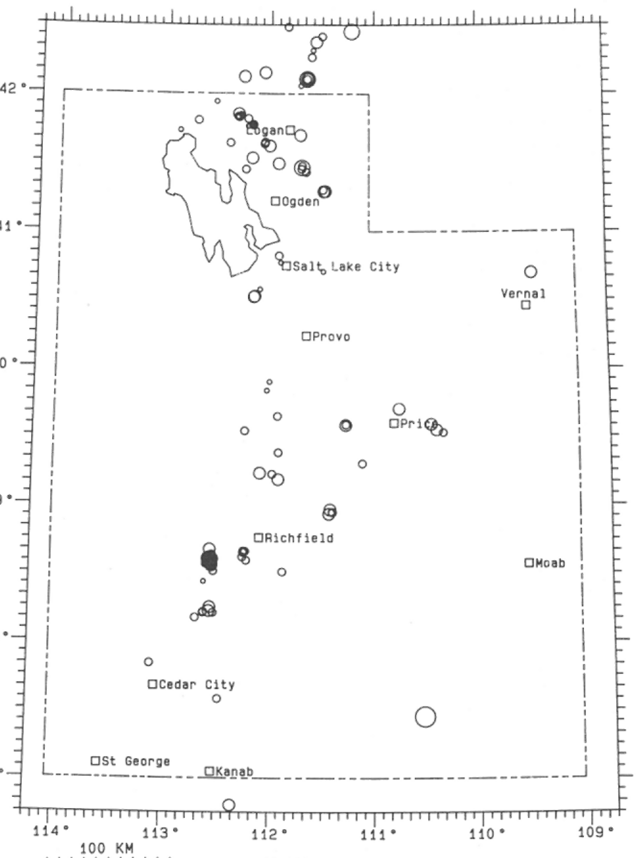
July through September, 1986

By ETHAN D. BROWN

UNIVERSITY OF UTAH SEISMOGRAPH STATIONS
DEPARTMENT OF GEOLOGY AND GEOPHYSICS

The Utah Seismograph Stations records an 81-station seismic network designed for local earthquake monitoring within Utah, southeast Idaho, and western Wyoming. During July 1 to September 30, 1986, 106 earthquakes were located within the Utah region, including 41 greater than magnitude 2.0. The epicenters shown in the seismograph map reflect typical earthquake activity scattered throughout Utah's main seismic region. The largest earthquake during this time period, M_L 4.0, occurred on August 22, and was located 32 km southeast of Bullfrog Basin in southern Utah. This earthquake was not reported felt, probably because the epicentral area is sparsely populated. In the northern part of the report area two earthquakes were felt during the July-September period. The first felt, M_L 3.2, event occurred on August 29 about 40 km north of Logan, Utah, and was felt in Preston, Idaho. The second earthquake, M_L 3.5, occurred on September 19 about 35 km northeast of Ogden, and was felt throughout southern Cache Valley.

Besides small clusters of earthquakes associated with the two described felt earthquakes, the map shows a significant cluster of activity 50 km southwest of Richfield. Activity there began on July 24 and continued intermittently to the end of the report period by which time a total of 18 earthquakes $M \leq 3.1$ had been located. These events are located near the Roosevelt geothermal area, although at this time it is uncertain whether or not the activity is related to the geothermal field.



Additional information on earthquakes within Utah is available from the University of Utah Seismograph Stations, Salt Lake City, Utah 84112; telephone (801) 581-6274.

FROM THE DIRECTOR'S DESK

Continued from Page 2

this regional information at a scale which provides a framework for the interpretation of exploration data. With this regional information in hand, the exploration company is able to focus more of its resources on the detailed and costly job of physical exploration (such as drilling) for ore deposits.

Preparing for the Next "Boom"

The mining industry suffers from cyclic "booms" and "busts." The current state of the industry can certainly be called a "bust," one of its very worst. Hopefully it is just a question of time before prosperity returns to the industry. Even so, it appears that the nature of the industry may have changed fundamentally in response to world markets and a shift in the nation's needs for specialty materials. The "good old days" for mining geologists may be gone forever.This probably makes UGMS studies all the more important in attracting interest to the state. With Utah's long history of mining and favorable geologic terrain, future exploration should lead to new discoveries of mineral deposits in Utah. Geological, geochemical, and geophysical data are all helpful before an organization commits to an exploration program. Future exploration will tend to be concentrated (initially, at least) in areas for which sufficient data are available. By publishing mining district and other studies during the "bust" years, the state can hope to attract exploration when the economy picks up.

Opportunities for UGMS

During "boom" periods, exploration is highly competitive and a veil of secrecy can envelop industry projects. During this bust cycle surviving exploration companies have been much more open about their activities and generous in sharing their data. The UGMS has enjoyed tremendous support from claim owners and exploration companies in recent years, and has been given access to data that would have cost the state hundreds of thousands of dollars to collect. This private support is invaluable in regional assessments and the production of quality publications. Another aspect of the current "bust" period is the loss of many of the major exploration companies such as Getty Minerals Company, Anaconda Minerals Company, and most of the minerals divisions of the major oil companies. In some cases the loss of a minerals company also means the loss of extensive files of exploration data that cost millions of dollars to collect over many years. Anaconda's files became public information at the University of Wyoming through devoted efforts of exploration geologists and far seeing management. This is unusual. Many precious reports and maps have been shredded, left to disintegrate in warehouses or, worse yet, bulldozed under rubble. A more aggressive attempt should be made to rescue this data. The UGMS is a repository for information and can accomodate confidential as well as public domain data.

Encouraging Exploration

Conclusions reached in mining district studies encourage the minerals industry by suggesting where the likelihood for discoveries in a district occur, possibly saving thousands of dollars and months of effort and enticing industry to invest many thousands more in the exploration phase. Depending on the land siutation in a particular district, a district study could spark immediate exploration interest. UGMS does not divulge any information to a specific company or to the public during a mining district study until the study is complete and released as an open-file report. This is done to ensure fair competition. A mining district study, when completed, becomes a permanent asset of a district, often remaining as the primary source of information on the district for many decades.

As a state agency, the UGMS policy towards the mining industry must fall within two extremes, 1) providing no assistance to the mining industry, and 2) doing work that is more effectively done by industry. The publication of mining district studies supports industry without doing their jobs. This is possible because the UGMS and industry activities are directed at different levels of detail.

The UGMS maps at broad, regional scales such as 1:100,000 county maps, 1:24,000 quadrangle maps, and at the most detailed, at 1:12,000 for special projects. Industry finds all this information useful. Their detailed exploration programs generally delineate the resource area at a 1:6,000 scale. They later generate development plans at a 1:600 to 1:200 scale.

Thus, the UGMS studies attract industry interest to a region and we believe they are one of the best ways for UGMS to promote the economic development of Utah's geologic resources. This issue of Survey Notes highlights Mike Shubat's mining district study in southwestern Utah (the Antelope Range Mining District). ■

Genevieve Atwood

GREAT SALT LAKE LEVEL

Date (1986)	Boat Harbor South Arm (in feet)	Saline North Arm (in feet)
July 1	4211.40	--
July 15	4211.30	4210.45
Aug 1	4211.15	4210.40
Aug 15	4211.00	4210.25
Sept 1	4210.85	4210.05
Sept 15	4210.70	4209.90
Oct 1	4210.80	4209.80
Oct 15	4210.85	4209.90
Nov 1	4210.95	4210.00
Nov 15	4210.95	4210.00
Dec 1	4211.05	4210.10
Dec 15	4211.10	4210.20

Source: USGS provisional records.

Congratulations!...

to former UGMS geologist, ***Howard Ritzma.*** Due to his dedication and exceptional contributions he has received the Distinguished Public Service to the Earth Sciences Award from the Rocky Mountain Association of Geologists. Mr. Ritzma was honored with this award on November 22, 1986 at the Association's annual meeting in Denver, Colorado.

Society of Mining Engineers...

held their 1987 Annual Meeting and Exhibit February 24-27 in Denver, Colorado. Technical sessions included four specialty symposia:

- MINERAL RESOURCE MANAGEMENT BY PERSONAL COMPUTERS
- CHEMICAL REAGENTS IN THE MINERAL PROCESSING INDUSTRY
- CONSTRUCTION AGGREGATE MATERIALS
- GEOTECHNICAL ASPECTS OF HEAP LEACH DESIGN

UGMS Staff Changes

The following staff changes have taken place since last issue:

Paul Sturm, who has given the Survey 9 years of service in the study of lake brines will now be using his expertise in private industry.

Also joining the ranks of private industry is **Keith Clem**, former UGMS petroleum geologist.

The Applied Geology Program, without a secretary since **Brenda Larsen** opted for full-time motherhood, now has **Sharon Wakefield** who has been with UGMS for several months.

Bill Black has taken the position of geotech receptionist.

Jordeane Dent left the UGMS to enjoy New Zealand and Australia. **Michael Laine** has taken over her position as curator of the sample library.

GSA Annual Meeting Dates...

and locations have been confirmed and released for publication as follows:

Year	Location	Dates	General Chairman
1987	Phoenix	Oct. 26-29	William R. Dickinson
1988	Denver	Oct. 31-Nov. 3	Robert J. Weimer
1989	St. Louis	Nov. 6-9	Brian J. Mitchell
1990	Dallas	Oct. 29-Nov. 1	To Be Announced
1991	San Diego	Oct. 21-24	To Be Announced
1992	Cincinnati	Oct. 26-29	To Be Announced
1993	Boston	Oct. 25-28	To Be Announced

UGMS/Salt Lake County Geologists Prepare Paper on Geology of Salt Lake City

A paper titled "Geology of Salt Lake City" is presently being jointly prepared by geologists of the Utah Geological and Mineral Survey and Salt Lake County. When complete, it will be published in the *Bulletin of the Association of Engineering Geologists* as part of the Association's "Geology of the Cities of the World" series. The primary focus of the paper is on the various engineering geologic aspects of Utah's largest metropolitan area. In adddition to a general overview of Salt Lake City's geologic setting and the geotechnical factors that influenced its settlement, topics to be covered include geologic constraints and hazards, geotechnical characteristics of rock and soil units, environmental concerns, major engineering structures, construction materials, use of underground space, and seismicity. A special section of the Great Salt Lake and other features of interest will also be included.

It is anticipated that the paper will be published in either the Winter 1987 or Spring 1988 volume of the AEG Bulletin. Reprints of the paper and accompanying maps will be available from the publication sales office of the UGMS.

UNIVERSITY OF NEVADA RENO...

will co-sponsor with Reno's Mackay School of Mines and Division of Continuing Education, a short course entitled ***Sampling of Gold: Theory and Practice.*** This will be offered on April 13-15, 1987 and the fee will be $450.00 per person. For further information contact Leanne Stone, Program Coordinator at Mining, University of Nevada-Reno, Division of Continuing Education, Reno, NV 89557-0032, (702) 784-4046.

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NEW PUBLICATIONS

Maps

Map 88, *Geologic map of the Honeyville quadrangle, Box Elder and Cache Counties, Utah,* by C.G. Oviatt, 1986. Two plates, four color, scale 1:24,000, with a 13-page booklet.

This map and Map 91 cover an area in the northern Wellsville Mountains, the north end of the Wasatch Range, which lies in the Basin and Range physiographic province as well as in the foreland of the Sevier orogenic belt.

Map 90, *Provisional geologic and coal resources map of the Mt. Ellen quadrangle, Garfield County, Utah,* by L.B. Morton, 1986. Three plates, four color, scale 1:24,000, with a 15-page booklet.

The Mt. Ellen quadrangle is at the northern end of the Henry Mountains and contains coal outcrops in the Ferron and Muley Canyon Sandstones. Plate three is a structure contour map of the Ferron Sandstone.

Map 91, *Geologic map of the Cutler Dam quadrangle, Box Elder and Cache Counties, Utah,* by C.G.Oviatt, 1986.Two plates, four color, scale 1:24,000, with a 7-page booklet.

Map 93, *Geologic map of the Lucin 4 NW quadrangle, Box Elder County, Utah,* by L.L. Glick and D.M. Miller, 1986. Two plates, four color, scale 1:24,000, with a 4-page booklet.

This map and Map 96 are part of an on-going project by U.S.G.S. mappers to cover a large area in northwest Utah which also includes Tecoma, Lucin, Pigeon Mountain, and Jackson quadrangles which will be available from the Utah Geological and Mineral Survey.

Map 96, *Geologic map of the Lemay Island quadrangle, Box Elder County, Utah,* by D. M. Miller and L. L. Glick, 1986. Two plates, four color, scale 1:24,000, with a 9-page booklet.

Special Studies

Special Studies 67, *Low-temperature geothermal assessment of the Santa Clara and Virgin River Valley, Washington County, Utah,* by K.E. Budding and S.N. Sommer, 1986.

The geothermal study of the St. George basin encompasses 250 square miles in south-central Washington County and is based primarily on 1) a temperature survey of springs and wells, 2) chemical analyses and calculated geothermometer temperatures from samples and from the literature, and 3) geology. In addition to known thermal areas Pah Tempe and Veyo Hot Springs, an area north of Washington and St. George is delineated for low-temperature geothermal potential. All potential areas appear to be related to structure rather than recent igneous activity.

Special Studies 68, *Engineering geologic case studies in Utah, 1986,* edited by W.R. Lund.

The Site Investigations Section of the UGMS responds to a variety of requests from cities, towns, counties, special service districts, and other state agencies for projects concerning geology and hazards. This publication is a collection of reports generated by five recent projects; it is typical of the work done by the section and exhibits a variety of techniques and methodologies. Titles of the reports: "Geologic and Hydrologic Evaluation of Mt. Pleasant Watershed, Sanpete County, Utah" by H.E. Gill;"Geologic Evaluation of Septic Tank and Soil Absorption System Suitability, Dry Fork Canyon, Uintah County, Utah" by W.R. Lund; "Engineering Geology for Land-Use Planning, Smithfield, Utah" by G.E. Christenson; "Preliminary Geologic Evaluation of Five Proposed Hazardous Waste-Facility Sites in Utah" by W.R. Lund; "Engineering Geology for Land-Use Planning for Research Park, University of Utah, Salt Lake City, Utah" by R.H. Klauk.

Open File Reports

Open File Report 91, *Geologic map of Little Creek Peak quadrangle, Iron and Garfield Counties, Utah,* by J.J. Anderson, T.A. Iivety, and P.D. Rowley, 1986.

Continued on back

Open File Report 92, *Geologic map of Panguitch NW quadrangle, Iron and Garfield Counties, Utah,* by J.J. Anderson and P.D. Rowley, 1986.

Open File Report 93, *Geologic map of Mt. Escalante quadrangle, Iron County, Utah,* by M.A. Siders, 1986.

Open File Report 94, *Geologic map of Thatcher Mountain quadrangle, Box Elder County,* by T.E. Jordan et al., 1986.

Open File Report 95, *Geologic map of Howell quadrangle, Box Elder County,* by T.E. Jordan et al., 1986.

Open File Report 96, *Memorandum of Progress, Delta, Utah 2-degree CUSMAP: Overview of geologic aspects of the Delta, Utah 2-degree quadrangle area.* A presentation of all mapping done in the quadrangle compiled by Lehi F. Hintze.

Open File Report 97, *Geology of Kane County, Utah,* by Hellmut H. Doelling, 1986.

Open File Report 98, *Geologic map of Aurora quadrangle, Sevier County, Utah,* by Grant C. Willis, 1986.

Open File Report 99, *Geologic map of Silver Peak quadrangle, Iron County,* by M.A. Shubat and M.A. Siders, 1986.

The releases above are in review to become four-color publications in our 7.5 minute geologic map series. Open-file status makes the information available to the public in the interim, and copies of the maps and booklets may be viewed in the U.G.M.S. Library during working hours.

Open File Report 100, *Argyle Canyon-Willow Creek Tar Sand Deposit Isopach Map,* by Bryce Tripp, 1986, 1:50,000.

Open File Report 101, *Argyle Canyon-Willow Tar Sand Deposit Overburden Map,* by Bryce Tripp, 1986, scale 1:50,000.

These two maps by Bryce Tripp constitute a reconnaissance mapping of the surface tar sands resources in the Argyle Canyon and Willow Creek area of Duchesne County, Utah. Each map is 44″ x 19″ and sells for $1.20 over the counter.

Reports of Investigation

Report of Investigation 212, *Engineering geology for land-use planning for a parcel of state-owned land east of Washington, Washington County, Utah,* by R.H. Klauk and Wm. Mulvey, 1986, 34 p.

An investigation was made to inventory geologic conditions on the property to allow the Division of State Lands to make informed decisions on future development.

Miscellaneous Publications

Miscellaneous Publication M, *Guidelines for preparing engineering geologic reports in Utah.*

This one-page flyer by the Guidelines Committee of the Utah Section of the Association of Engineering Geologists was developed as a general aid to professionals evaluating site-specific conditions.

Utah Geological Association Publication 15, *Thrusting and extensional structures and mineralization in the Beaver Dam Mountains, southwestern Utah,* editors: Dana T. Griffen and W. Revell Phillips. Price $25.00.

Grant G. Willis and Mark E. Jensen, UGMS mapping geologists, just had their master's theses published in BYU Geology Studies series of December 1986;

Mark's is "Tertiary geologic history of the Slate Jack Canyon quadrangle, Juab and Utah Counties, Utah;"

Grant's is "Geology, depositional environment, and coal resources of the Sego Canyon 7 1/2-minute quadrangle, near Green River, east-central Utah."

The Sego Canyon map by Grant and another in the same publication, "Geology of the Deadman Canyon 7 1/2-minute quadrangle, Carbon County, Utah" by Mark Nethercott have been produced by the UGMS under the quadrangle mapping series as maps 76 and 89.